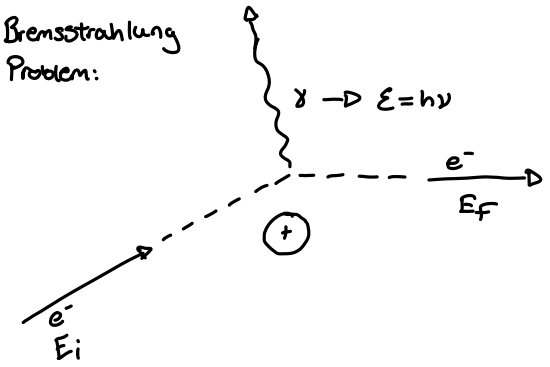
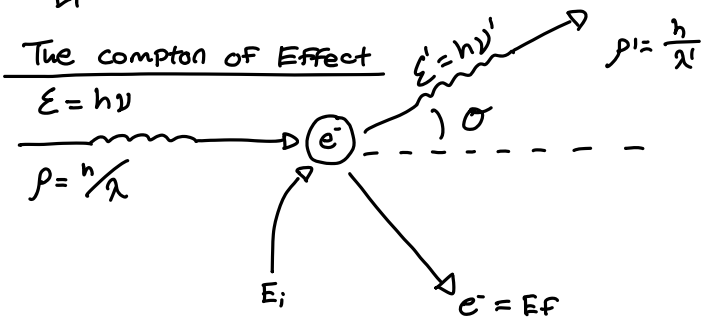
Strait outtac Compton Effect

Compton Scattering

Bremsstrahlung Problem:



The compton of Effect



we will need these results from Special Relativity:

(1) Relativistic Energy

$$E_e^2 = (mc^2)^2 + p_e^2c^2$$

(2) Photon momentum

$$p_\gamma = \frac{E}{c} = \frac{h\nu}{c} = \frac{h}{\lambda}$$

Invoke Conservation of Energy & momentum

(1) $\mathcal{E} + E_i = \mathcal{E}' + E_f \longrightarrow h\nu + mc^2 = h\nu' + E_f$

(2) $p_x = p_x' + p_{ex}$

$p_x = p'\cos\theta + p_e\cos\theta \longrightarrow \frac{h}{\lambda} = \frac{h}{\lambda'}\cos\theta + p_e\cos\phi$

(3) $p'\sin\theta = p_e\sin\theta$

$\longrightarrow \frac{h}{\lambda'}\sin\theta = p_e\sin\phi$

$$\left(\frac{h}{\lambda} - \frac{h}{\lambda'}\cos\theta\right)^2 = p_e^2\cos^2\phi + \left(\frac{h}{\lambda'}\right)^2\sin^2\theta = p_e^2\sin^2\phi$$

$$\left(\frac{h}{\lambda} - \frac{h}{\lambda'}\cos\theta\right)^2 + \left(\frac{h}{\lambda'}\right)^2\sin^2\theta = p_e^2$$

$$\frac{h^2}{\lambda^2} - \frac{2h^2}{\lambda\lambda'}\cos\theta + \frac{h^2}{\lambda'^2}\cos^2\theta + \frac{h^2}{\lambda^2}\sin^2\theta = p_e^2$$

$$\frac{h^2}{\lambda^2} - \frac{2h^2}{\lambda\lambda'}\cos\theta + \frac{h^2}{\lambda'^2} = p_e^2$$

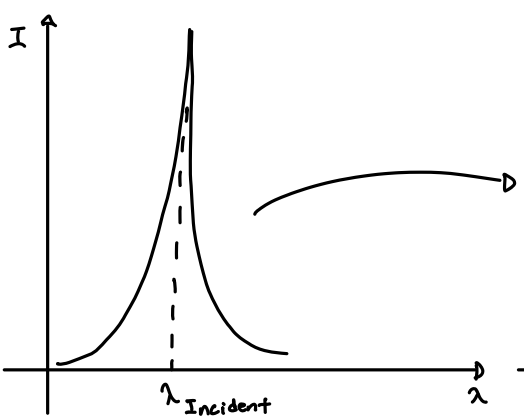
$$E_f = h(\nu - \nu') + mc^2$$

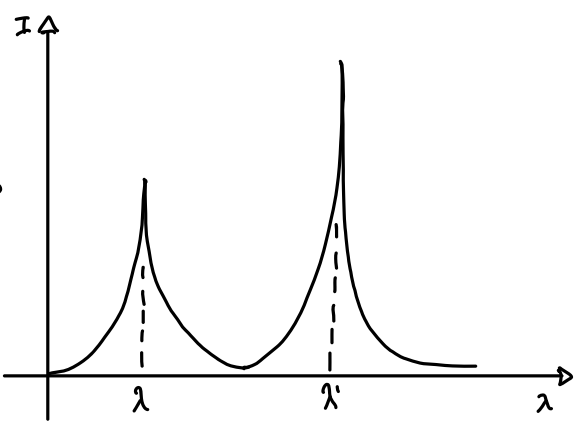
$$\left[h(\nu - \nu') + mc^2\right]^2 = (mc^2)^2 + \left[\frac{h^2}{\lambda^2} + \frac{h^2}{\lambda'^2} - \frac{2h^2}{\lambda\lambda'}\cos\theta\right]c^2$$

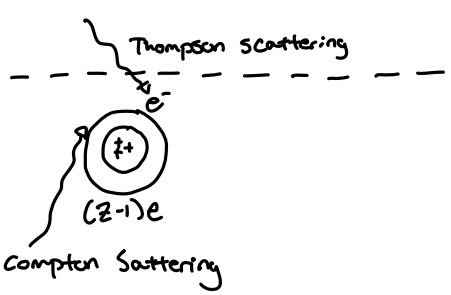
After Simplification

$$\frac{h}{mc^2}(1 - \cos\theta) = \frac{1}{c}\underbrace{(\lambda' - \lambda)}_{\Delta\lambda}$$

$$\Delta\lambda = \frac{h}{mc}(1 - \cos\theta)$$







$$\Delta\lambda_c = \frac{h}{mec}(1 - \cos\theta)$$

$$\Delta\lambda_T = \frac{h}{2Zmpc}(1 - \cos\theta)$$

$$\frac{\Delta\lambda_T}{\Delta\lambda_c} = \frac{me}{2Zmp} = \frac{1}{2Z}\frac{1}{1836}$$

$\lambda = 0.050\,nm$ Incident on Gold

$\mathcal{E}_{Binding} \sim 62\,keV$

$E = \frac{1.24 \times 10^3 eV \cdot nm}{0.050\,nm} = 28\,keV < 62\,keV$

Chapter 3 Summary

- Experimental Evidence showed:
  1) Neutral matter composed of charged parts
  2) Charge is Quantized (Millikan, Thompson)
  3) Mass is Quantized (3.1-3.4)
  4) Line spectra hint at (Quantized) internal Structure of Atoms
- Blackbody Radiation: Suggests radiation occurs in packets (Quanta) of discrete energy $\sim h\nu$ (3.5)
- Photo Electric Effect: Proves $\mathcal{E} = h\nu$ are "Elements of physical reality" (3.6)
- X-Ray production & scattering further proof that light behaves like a particle. (3.7 - 3.9)